Attachment #2

Revised Issaquah Ammonia Leak Estimate (10/7/09):

The leak was located at a 0.5 inch compression fitting around the outside diameter next to the compression nut. In an attempt to best determine the amount of ammonia released we have converted the annular region around the tubing into an equivalent diameter by estimating the crack around this to be 0.004 inch around the tube. In doing this, the leak can be modeled by the equation below:

Cross sectional area:

$A_{leak} = A_{out} - A_{fitting}$

Where

A_{leak} = Area of annular leak space (square inches)
A_{out} = Area of circle whose diameter is 0.004 inch beyond fitting diameter (square inches)
$A_{fitting}$ = Area of fitting cross section (square inches)

$A_{out} = \pi \times d_{out}^2/4 = 3.1416 \times (.5 + .004)^2 /4 = 0.197136$ sq in

$A_{fitting} = \pi \times d_{fitting}^2/4 = 3.1416 \times (.5)^2 /4 = 0.196350$ sq in

A_{leak} = 0.003154 sq in

Gaseous Ammonia Release from System:

Source: Chapter 7.1.1.EPA CEPP Risk Management Program Guidance for Offsite Consequence Analysis EPA 550-B-99-009, April 1999

$QR = HA \times P_t \times 1/\sqrt{(T_t)} \times GF$

Where

QR = Release rate (pounds per minute)

HA = Hole area (square inches from best estimate) = A_{leak} = 0.003154 sq in

P_t = Pressure in system in psia = 135 + 14.7 = 149.7 psia

T_t = Tank temperature (K), where K is absolute temperature in Kelvin = 25 + 273 = 298 K

GF = Gas factor for ammonia (Exhibit B-1 of source document above) = 14

Therefore:

QR = 0.003154 x 149.7 x 1 / $\sqrt{298}$ x 14 = 0.212175 pounds per minute ammonia leak

Gas Leak = 0.38407 pounds per minute x 180 minutes = 69.13 pounds

Observation of Liquid Loss from System:

Estimated Loss Rate of Ammonia Liquid = At about one ml per drop	30 Drops / min
Time period of release = 2 hours =	120 Minutes
Density of liquid ammonia at boiling point = and 1 atmosphere	682 kg / meter^3
=	0.682 g / ml
One pound =	453 grams

Therefore:

Liquid Ammonia Release = (30) x (0.682) x (180) / (453) = 8.13 pounds

Total Release 77.26 pounds

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